

**EXOPALEONTOLOGICAL SEARCH STRATEGY FOR MARS EXPLORATION: A CASE FOR SILICEOUS EPITHERMAL DEPOSITS.** Sherry L. Cady<sup>1</sup>, Malcolm R. Walter<sup>2</sup>, David J. Des Marais<sup>1</sup>, and Carrine E. Blank<sup>3</sup>, <sup>1</sup>NASA Ames Research Ctr, M/S N239-4, Moffett Field, CA 94035; <sup>2</sup>School of Earth Sciences, Macquarie Univ, North Ryde, NSW Australia ; <sup>3</sup>Molecular and Cell Biology, Univ of California, Berkeley, CA 94720.

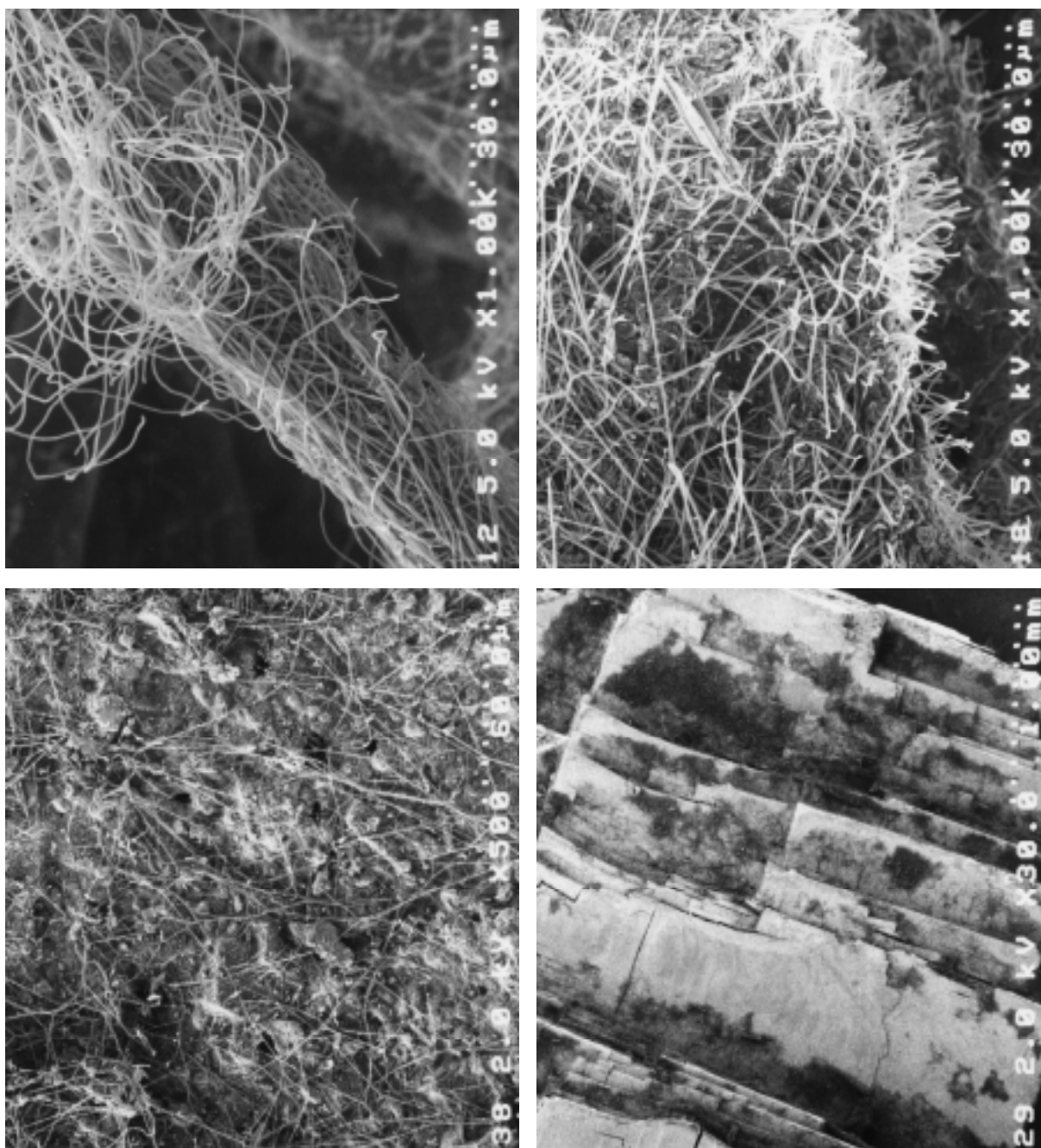
The thermophilic lifestyle of the last common ancestor of extant life on Earth [1] suggests that the subaerial parts of hydrothermal deposits could be excellent targets for future exopaleontological exploration on the surface of Mars [2]. The juxtaposition of the source areas of stream valley channels with volcanoes and impact craters on Mars implies that subsurface heating of groundwater must have created thermal springs in the past [3]. Modern thermal spring ecosystems on Earth concentrate a wide diversity of thermophilic organisms into small areas [4]. Because they are very active mineralizing environments, hydrothermal systems also have an enhanced potential to preserve evidence of biogenicity as chemofossils, microfossils, or stromatolites.

Subterranean components of thermal spring systems have been recognized as potentially hospitable environments for extant life on Mars [5][6][7]. We propose that subterranean hydrothermal deposits should also be targeted for evidence of former life on Mars [8][9]. The lateral extent of subaerial thermal spring ecosystems on Earth is dwarfed in comparison to potentially habitable subterranean environments. By evaluating the biogenicity of epithermal deposits, we can optimize our attempts to identify the potential for hydrothermal ecosystems to serve as paleobiological repositories. Recent investigations [10][11] have shown that even in the absence of visible microbial mats, hyperthermophilic biofilms contribute to the microstructural and morphological development of high-temperature siliceous sinter deposits previously considered to be abiogenic. Although submicron-scale features indicative of biogenicity are often masked by the recrystallization of primary metastable opaline silica, these features propagate to form larger scale stromatolitic structures recognizable in the rock record. These findings have motivated us to look for evidence of biogenicity in epithermal systems. Additionally, we have found that various types of substrates deployed at vent openings in the bottoms of active silica-depositing thermal springs became colonized within days by hyperthermophilic organisms that live near the upper temperature limit of life (Figures 1-4). The filamentous hyperthermophiles stabilize themselves by attaching to the substrate surfaces and form biofilms that can be several cell diameters thick. We propose that the high fluid flow rates in the main fracture systems of epithermal deposits will focus biofilm development at particular locations along the walls of hydrothermal conduits. We have found that those deployed substrates characterized by flat surfaces have relatively even distributions of biofilms, whereas mineral substrates with stepped surfaces have discontinuous biofilm formation. Our findings suggest that biofilms will develop along fracture walls where the rate of exchange of solutes between the biofilms and the flowing water is optimized.

Given the potential for life to exist at temperatures in excess of 113°C [12], it is apparent that we must re-evaluate the contribution of hyperthermophilic organisms to epithermal components of hydrothermal mineral deposits. Our recent efforts [10][11][13] emphasize the importance in understanding the submicron-scale processes and organosedimentary interactions by which biogenically influenced sediment microstructures and morphologies were formed. While the recrystallization of primary mineral assemblages challenges our ability to recognize the biogenicity of ancient siliceous hydrothermal deposits on Earth, the recent report of nanometer-scale microfossil-like objects in the Allan Hills Martian meteorite [14] indicates that recrystallization might not frustrate our attempts to identify the biogenicity of hydrothermal deposits formed under similar conditions on Mars. If we can recognize in the rock record and interpret confidently the macroscale features and microstructures of ancient epithermal deposits formed in the presence of biofilms, we will have taken great strides in our ability to unravel the early fossil record of hyperthermophilic life on Earth and, potentially, on Mars.

References: [1] Pace NR (1991) *Cell* 65, 531. [2] Kerridge JF (1995) (Ed) NASA Spec. Pub. 530. [3] Brakenridge GR et al (1985) *Geology* 13, 859. [4] Walter MR & Des Marais DJ (1993) *Icarus* 101, 129. [5] Gold T (1992) *Proc. Nat. Acad. Sci.* 89, 6045. [6] Boston PJ et al (1992) *Icarus* 95, 300. [7] McKay CP & Stoker CR (1989) *Rev. in Geophys.* 27, 189. [8] Walter MR (1996) In *Evolution of Hydrothermal Ecosystems on Earth (and Mars?)* Bock GR & Goode JA (Eds) Wiley, 112-130. [9] Henley RW (1996) *Ibid*, 61-82. [10] Cady SL et al (1995) *GSA [Abs]* 27(6), A304. [11] Cady SL & Farmer JD (1996) In *Evolution of Hydrothermal Ecosystems on Earth (and Mars?)* Bock GR & Goode JA (Eds) Wiley, 150-173. [12] Stetter KO (1996) *Ibid*, 1-18. [13] Blank CE et al (submitted) 1997 ASM Annual Meeting, May 4-8, Miami, FL. [14] McKay DS et al (1996) *Science* 273, 924.

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Various substrates deployed around vent openings in near-boiling silica-depositing thermal springs located in Yellowstone National Park.

Fig. 1 (plate 12) Fiber of coupon colonized by filamentous hyperthermophilic organisms < 0.5 microns in diameter and several microns long.

Fig. 2 (plate 18) Filaments lie parallel to the top surface of a clay substrate, shorter filaments lie perpendicular to edge of stepped surface of substrate.

Fig. 3 (plate 38) Porcelain fragment colonized by evenly dispersed hyperthermophilic biofilm that contains filaments like the ones shown in Fig. 1.

Fig. 4 (plate 29) Stepped faces on galena crystal colonized by discontinuous biofilms that contain long filaments, rod-shaped microbes and silicified microfossils.